

CLAIMS

What is claimed is:

1. A method of converting an organometallic precursor material to a metal-containing pattern adherent to a substrate, comprising:
 - 5 applying the organometallic precursor material in an amount sufficient to coat at least a portion of the substrate, wherein said organometallic precursor material is adapted to be converted to form a metal or metal oxide;
 - pre-converting the organometallic precursor material by exposing the organometallic precursor material to a pre-conversion energy exposure dose such that the
10 pre-converted precursor material is not converted to a degree sufficient to impair pattern resolution;
 - pattern converting a portion of the pre-converted precursor material to convert this portion to a pattern-converted material to an extent sufficient to thereby form a pattern on the substrate; and
 - 15 developing the portion of the pre-converted precursor material that was not pattern-converted such that the pattern remains on the substrate after developing.
2. The method of claim 1, wherein the pattern conversion comprises exposing the pre-converted precursor material to a patterning energy exposure dose, which
20 converts the pre-converted precursor material to metal or metal oxide that adheres to the substrate to an extent sufficient to thereby form a deposited pattern thereon.
3. The method of claim 2, wherein the pre-conversion energy exposure dose is selected to be about 20% or less of the combination of the pre-conversion energy
25 exposure dose and the patterning energy exposure dose, such that the pre-converted precursor material is substantially developable.
4. The method of claim 2, wherein the pre-conversion energy exposure dose is selected to be from about 20% to about 50% of the combination of the pre-
30 conversion energy exposure dose and the patterning energy exposure dose, such that the pre-converted precursor material is substantially developable.
5. The method of claim 1, wherein the pre-conversion, the pattern-conversion, or both, comprises photochemical metal organic deposition.

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6. The method of claim 1, wherein the pre-conversion comprises forming a metal or metal oxide within the organometallic precursor material.

7. The method of claim 1, wherein the pre-conversion energy exposure dose is selected to be from about 30% to about 80% of a maximum pre-conversion energy exposure dose, wherein the maximum pre-conversion energy exposure dose is that energy dose above which the organometallic precursor material exposed to the pre-conversion energy exposure dose is no longer substantially developable or above which the organometallic precursor material exposed to the pre-conversion energy exposure dose adheres to the substrate to a degree sufficient to impair pattern resolution, wherein the organometallic precursor material exposed to the pre-conversion energy exposure dose is substantially developable.

8. The method of claim 1, wherein the pre-conversion energy exposure dose is selected to be about 50% or more of a maximum pre-conversion energy exposure dose, wherein the maximum pre-conversion energy exposure dose is that energy dose above which the organometallic precursor material exposed to the pre-conversion energy exposure dose is no longer substantially developable or above which the organometallic precursor material exposed to the pre-conversion energy exposure dose adheres to the substrate to a degree sufficient to impair pattern resolution, wherein the organometallic precursor material exposed to the pre-conversion energy exposure dose is substantially developable.

9. The method of claim 1, wherein the pre-conversion energy exposure dose is selected to be from about 60% to about 99% of a maximum pre-conversion energy exposure dose, wherein the maximum pre-conversion energy exposure dose is that energy dose above which the organometallic precursor material exposed to the pre-conversion energy exposure dose is no longer substantially developable or above which the organometallic precursor material exposed to the pre-conversion energy exposure dose adheres to the substrate to a degree sufficient to impair pattern resolution, wherein the organometallic precursor material exposed to the pre-conversion energy exposure dose is substantially developable.

10. A substrate containing a patterned metal or metal oxide layer formed according to the method of claim 1.

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11. The method according to claim 1, wherein the pre-conversion comprises exposing the precursor material to a heat source, and wherein the pattern-conversion comprises exposing the pre-converted precursor material to a light source.

5 12. The method according to claim 1, wherein the pre-conversion comprises exposing the precursor material to a heat source, and wherein the pattern-conversion comprises exposing the pre-converted precursor material to an electron-beam source.

10 13. The method according to claim 1, wherein the pre-conversion comprises exposing the precursor material to an electron-beam source, and wherein the pattern-conversion comprises exposing the pre-converted precursor material to a light source.

15 14. The method according to claim 1, wherein the pre-conversion comprises exposing the precursor material to a light source, and wherein the pattern-conversion comprises exposing the pre-converted precursor material to a light source.

20 15. A method of converting an organometallic precursor material to a metal-containing pattern adherent to a substrate, comprising:

applying the organometallic precursor material in an amount sufficient to coat at least a portion of the substrate, wherein said organometallic precursor material is adapted to be converted to form a metal or metal oxide;

25 pre-converting the organometallic precursor material by exposing the organometallic precursor material to a pre-conversion energy exposure dose such that the pre-converted precursor material is not converted to a degree sufficient to impair pattern resolution;

30 pattern converting a first portion of the pre-converted precursor material to convert this portion to a pattern-converted material to an extent sufficient to thereby form a first pattern on the substrate;

pattern converting a second portion of the pre-converted precursor material to convert this portion to a pattern-converted material an extent sufficient to thereby form a second pattern on the substrate; and

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developing the second portion of the pre-converted precursor material that was pattern-converted such that the second pattern remains on the substrate after developing.

5 16. The method of claim 15, wherein the pattern conversion comprises exposing the pre-converted precursor material to a patterning energy exposure dose, which converts the pre-converted precursor material to metal or metal oxide that adheres to the substrate to an extent sufficient to thereby form a deposited pattern thereon.

10 17. The method of claim 16, wherein the pre-conversion energy exposure dose is selected to be about 20% or less of the combination of the pre-conversion energy exposure dose and the patterning energy exposure dose, such that the pre-converted precursor material is substantially developable.

15 18. The method of claim 16, wherein the pre-conversion energy exposure dose is selected to be from about 20% to about 50% of the combination of the pre-conversion energy exposure dose and the patterning energy exposure dose, such that the pre-converted precursor material is substantially developable.

20 19. The method of claim 15, wherein the pre-conversion, the pattern-conversion, or both, comprises photochemical metal organic deposition.

 20. The method of claim 15, wherein the pre-conversion comprises forming a metal or metal oxide within the organometallic precursor material.

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 21. The method of claim 15, wherein the pre-conversion energy exposure dose is selected to be from about 30% to about 80% of a maximum pre-conversion energy exposure dose, wherein the maximum pre-conversion energy exposure dose is that energy dose above which the organometallic precursor material exposed to the pre-conversion
30 energy exposure dose is no longer substantially developable or above which the organometallic precursor material exposed to the pre-conversion energy exposure dose adheres to the substrate to a degree sufficient to impair pattern resolution, wherein the organometallic precursor material exposed to the pre-conversion energy exposure dose is substantially developable.

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22. The method of claim 15, wherein the pre-conversion energy exposure dose is selected to be about 50% or more of a maximum pre-conversion energy exposure dose, wherein the maximum pre-conversion energy exposure dose is that energy dose above which the organometallic precursor material exposed to the pre-conversion energy exposure dose is no longer substantially developable or above which the organometallic precursor material exposed to the pre-conversion energy exposure dose adheres to the substrate to a degree sufficient to impair pattern resolution, wherein the organometallic precursor material exposed to the pre-conversion energy exposure dose is substantially developable.

23. The method of claim 15, wherein the pre-conversion energy exposure dose is selected to be from about 60% to about 99% of a maximum pre-conversion energy exposure dose, wherein the maximum pre-conversion energy exposure dose is that energy dose above which the organometallic precursor material exposed to the pre-conversion energy exposure dose is no longer substantially developable or above which the organometallic precursor material exposed to the pre-conversion energy exposure dose adheres to the substrate to a degree sufficient to impair pattern resolution, wherein the organometallic precursor material exposed to the pre-conversion energy exposure dose is substantially developable.

24. A substrate containing a patterned metal or metal oxide layer formed according to the method of claim 15.

25. The method according to claim 15, wherein the pre-conversion comprises exposing the precursor material to a heat source, and wherein the pattern-conversion comprises exposing the pre-converted precursor material to a light source.

26. The method according to claim 15, wherein the pre-conversion comprises exposing the precursor material to a heat source, and wherein the pattern-conversion comprises exposing the pre-converted precursor material to an electron-beam source.

27. The method according to claim 15, wherein the pre-conversion comprises exposing the precursor material to an electron-beam source, and wherein the pattern-conversion comprises exposing the pre-converted precursor material to a light source.

28. The method according to claim 15, wherein the pre-conversion comprises exposing the precursor material to a light source, and wherein the pattern-conversion comprises exposing the pre-converted precursor material to a light source.

5 29. An apparatus for converting an organometallic precursor material to a metal-containing film adherent to a substrate formed by a method according to claim 1, comprising:

a load station to store the substrate before processing;
a means of delivering the substrate between processing steps;
10 a pre-convert section, wherein the substrate is coated, if previously uncoated, with a sufficient amount of the organometallic precursor material and is subjected to a first converting means in either a series or parallel arrangement;
a pattern convert section, wherein the organometallic precursor material coated on the substrate, subjected to a first converting means, and not covered by a mask is
15 substantially converted, using a second converting means, to form a metal-containing pattern adherent to the substrate; and
an unload station where the pattern-coated substrate is stored after processing.

20 30. The apparatus of claim 29, wherein the first and second converting means are the same or different, and wherein each comprises a heat source, a light source, a coherent light source, a broadband light source, an electron beam source, or an ion beam source.

25 31. An apparatus for converting an organometallic precursor material to a metal-containing film adherent to a substrate formed by a method according to claim 15, comprising:

a load station to store the substrate before processing;
a means of delivering the substrate between processing steps;
30 a pre-convert section, wherein the substrate is coated, if previously uncoated, with a sufficient amount of the organometallic precursor material and is subjected to a first converting means in either a series or parallel arrangement;
a pattern convert section, wherein the organometallic precursor material coated on the substrate, subjected to a first converting means, and not covered by a mask is
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substantially converted, using a second converting means, to form a metal-containing pattern adherent to the substrate; and

an unload station where the pattern-coated substrate is stored after processing.

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32. The apparatus of claim 31, wherein the first and second converting means are the same or different, and wherein each comprises a heat source, a light source, a coherent light source, a broadband light source, an electron beam source, or an ion beam source.

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33. A method of selecting a pre-conversion energy exposure dose and a patterning energy exposure dose to be used in converting an organometallic precursor material to a metal-containing patterned layer comprising at least two pattern elements that are adherent to a substrate, which method comprises:

15 determining a relationship between the pre-conversion energy exposure dose in the conversion and the amount of pre-converted precursor material that adheres to the substrate; and

selecting a pre-conversion energy exposure dose that is less than a maximum pre-conversion energy exposure dose, wherein the maximum pre-conversion energy exposure dose is that energy dose above which the organometallic precursor material exposed to the pre-conversion energy exposure dose is no longer substantially developable or above which the organometallic precursor material exposed to the pre-conversion energy exposure dose adheres to the substrate to a degree sufficient to impair pattern resolution, such that the patterning energy exposure dose yields an acceptable pattern resolution on the substrate,

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wherein the acceptable pattern resolution is such that the at least two elements of the metal-containing patterned layer are discrete and not connected by like material.

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34. The method of claim 33, further comprising identifying a maximum pre-conversion energy exposure dose based on the dose-conversion relationship, such that the organometallic precursor material exposed to the pre-conversion energy exposure dose, but not to the patterning energy exposure dose is substantially removable during developing.

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35. The method of claim 33, wherein the pre-conversion energy exposure dose is selected to be about 20% or less of the combination of the pre-conversion energy exposure dose and the patterning energy exposure dose, such that the pre-converted precursor material is substantially developable.

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36. The method of claim 33, wherein the pre-conversion energy exposure dose is selected to be from about 20% to about 50% of the combination of the pre-conversion energy exposure dose and the patterning energy exposure dose, such that the pre-converted precursor material is substantially developable.

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37. The method of claim 33, wherein the pre-conversion energy exposure dose is selected to be from about 30% to about 80% of a maximum pre-conversion energy exposure dose, wherein the maximum pre-conversion energy exposure dose is that energy dose above which the organometallic precursor material exposed to the pre-conversion energy exposure dose is no longer substantially developable or above which the organometallic precursor material exposed to the pre-conversion energy exposure dose adheres to the substrate to a degree sufficient to impair pattern resolution, wherein the organometallic precursor material exposed to the pre-conversion energy exposure dose is substantially developable.

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38. The method of claim 33, wherein the pre-conversion energy exposure dose is selected to be about 50% or more of a maximum pre-conversion energy exposure dose, wherein the maximum pre-conversion energy exposure dose is that energy dose above which the organometallic precursor material exposed to the pre-conversion energy exposure dose is no longer substantially developable or above which the organometallic precursor material exposed to the pre-conversion energy exposure dose adheres to the substrate to a degree sufficient to impair pattern resolution, wherein the organometallic precursor material exposed to the pre-conversion energy exposure dose is substantially developable.

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39. The method of claim 33, wherein the pre-conversion energy exposure dose is selected to be from about 60% to about 99% of a maximum pre-conversion energy exposure dose, wherein the maximum pre-conversion energy exposure dose is that energy dose above which the organometallic precursor material exposed to the pre-conversion energy exposure dose is no longer substantially developable or above which the organometallic precursor material exposed to the pre-conversion energy exposure dose

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adheres to the substrate to a degree sufficient to impair pattern resolution, wherein the organometallic precursor material exposed to the pre-conversion energy exposure dose is substantially developable.

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